SOLAR ENERGY COLLECTOR

FIELD OF THE INVENTION

This invention is in the field of solar energy systems and in particular in the field of solar energy collectors which use lenses to concentrate solar radiation for use in heat exchange applications.

BACKGROUND OF THE INVENTION

The use of lenses to concentrate solar radiation on an absorbing device is known in the art. Solar concentrators utilizing Fresnel lenses have also been disclosed in the prior art. U.S. Patent No. 5,915,376 to McLean discloses a solar heat collecting apparatus comprised of glass domes consisting of Fresnel lenses. Solar radiation entering the solar heat collecting apparatus is absorbed by an absorber plate, and transferred to a remote storage system by conventional heat transfer means.

U.S. Patent No. 6,384,320 to Chen discloses a compound parabolic concentrator (CPC) which is mounted under a Fresnel lens that concentrates the intensity of solar radiation to five to ten times above normal level. The focused solar radiation is further concentrated twenty to fifty times by the CPC collector. The intensified solar radiation is focused onto the top of a stainless steel heat pipe or heat exchanger.

The use of Fresnel lenses for concentrating solar energy is disclosed in U.S. Patent No. 6,399,874 to Olah, U.S. Patent No. 6,299,317 to Gorthala, and U.S. Patent No.'s 5,959,787 and 6,091,020 to Fairbanks. The devices disclosed in these patents provide for concentrating solar energy for photovoltaic cells.

It is an object of the present invention to provide a simplified, economical and efficient solar collector for heat transfer applications..

It is a further object of the present invention to provide a solar collector using a pipe for an energy absorber.

It is a further object of the present invention to provide a solar collector that is flexible as to the intensity, distribution and geometry of concentration of solar radiation on an energy absorber.

It is a further object of the present invention to provide a solar collector that incorporates an energy absorber with enhanced energy absorption efficiency.

It is a further object of the present invention to provide a solar collector that uses a pipe with an energy retaining capsule encapsulating the absorption zone as an energy absorber.

It is a further object of the present invention to provide a solar collector with a simple and economical solar tracking drive.

It is a further object of the present invention to provide a solar collector that is readily incorporated into a solar collector installation that is flexible as to size and geometry.

It is a further object of the present invention to provide a simple, economical and efficient solar collector installation.

It is a further object of the present invention to provide a solar collector installation that is simple and economical to operate and maintain.

It is a further object of the present invention to provide a solar collector installation that utilizes pipes as energy absorbers.

It is a further object of the present invention that provides a solar collector and energy extraction installation that is simple and economical to construct, operate and maintain.

SUMMARY OF THE INVENTION

The solar energy collector of the present invention uses one or more Fresnel lenses. Typically the Fresnel lens used for the present invention is a extruded or molded from a thin, lightweight plastic sheet with concentric grooves formed in one side of the lens. The grooves act as individual refracting surfaces, like small prisms when viewed in cross section, bending parallel rays in a very close approximation to a common focal length. Because the lens is thin, very little energy is lost by absorption.

For a preferred embodiment, the Fresnel lenses are mounted on a support frame above an absorption conduit which is typically a metal pipe. If the Fresnel lenses are designed for a point focus or a distributed focus on an absorption zone, the absorption conduit may have an energy absorber mounted on the conduit in the absorption zone which is enclosed in an energy retaining capsule with a high solar radiation transmission rate and a low thermal conductivity rate, thereby providing for transmission of the focused incident solar radiation to the absorption zone of the energy absorber while minimizing the loss of energy from the energy absorber to the surrounding air. An in-line or attached spherical energy absorber with a spherical energy retaining capsule or a hemispherical energy absorber with a hemispherical energy retaining capsule may be used. Alternatively, a spherical or hemispherical energy retaining capsule can simply be used to encapsulate an absorption zone on the absorption conduit. For a linear absorption zone, a cylindrical capsule is preferred on the absorption conduit. The absorbed energy is transferred to an absorption liquid flowing through the

absorption conduit.

An absorption fin can also be incorporated inside the energy absorber which extends into the absorption duct and is in contact with the absorption zone, thereby assisting in the transfer of energy to the absorption liquid which flows through the energy absorber. The absorption fin would normally be made of high thermal conductivity material thereby rapidly transferring the energy of the incident solar radiation from the absorption zone to the absorption liquid. A preferred material for the absorption zone and absorption fins is tungsten due to its high thermal conductivity rate, its high melting point and its glass to metal sealing capabilities.

Each Fresnel lenses is mounted on a support frame which is attached to a solar tracking drive. The solar tracking drive continually aligns each Fresnel lenses with the sun, during a desired period of operation, thereby providing for continual point focus or distributed focus of the incident solar radiation on an absorption zone of the energy absorber. The absorption conduit, or other energy absorber, can be positioned so that the Fresnel lens top surface is separated from the absorption conduit top surface by a distance which is equal to the focal length of the lens, thereby providing for the incident solar radiation to be focused at a single point in the absorption zone of the energy absorber or can be positioned such that incident solar radiation is distributed on a larger area of the absorption zone. If the incident solar radiation is focused on a single point in the absorption zone of the energy absorber, substantially higher temperatures will be experienced at the focal point. Having the focal point coincident with the center of the energy absorber, rather than a point on the surface of the energy absorber, results in distribution of the energy and therefore substantially reduced

temperatures. The focus of the incident solar radiation can be varied between the center of the absorption conduit and a point on the surface of the absorption conduit thereby varying the distribution of the focused solar radiation and thereby the maximum temperature experienced in the absorption zone.

Rather than a circular pattern of grooves, the Fresnel lenses may have longitudinal grooves which result in the incident solar radiation having a line focus rather than a single focal point. This offers an advantage of distributing the focused incident solar radiation over a larger area, thereby reducing the temperature of the absorption zone. The expanded absorption zone for embodiments utilizing a Fresnel lens with longitudinal grooves can be encapsulated in an energy retaining capsule with a high solar radiation transmission rate and low thermal conductivity rate such as glass. Other portions of the absorption conduit which do not receive focused incident solar radiation can be insulated or merely be covered with the energy retaining capsule material to reduce energy loss to the surrounding air. Similarly, Fresnel lenses with oval grooves may be used to provide for distribution of energy on the absorption zone as the lens will distribute the concentrated radiation on an expanded area rather than a single focus point. Further distribution of the energy can be accomplished, regardless of the pattern of grooving on the Fresnel lens, by positioning the Fresnel lenses so that the energy absorbers have absorption surfaces which are displaced radially from the focal point or focal line of the respective lenses. The extent of the distribution can be selected based upon the desired range of surface temperatures for the absorption zone.

The Fresnel lens itself is preferably constructed of an optically clear material. These materials include but are not limited to acrylic, glass, rigid vinyl, polycarbonate, polyethylene,

polyester blends including PET and PETG respectively, poly IR, polystyrene, polyurethane, polypropylene, polyacrylonitrile, Kevlar, Nomex, rubber, germanium, silicon, zinc sulfide, quartz and other such materials. The inventor's preferred materials are polyester (PET or PETG) or a blend thereof.

A Fresnel lens can be formed or manufactured in a number of ways from the substrate materials identified above. This includes but is not limited to press thermalforming, roll thermalforming, casting, emboss extruding, injection molding, milling, lathing, or UV curing. Emboss extrusion is the preferred method of creating Fresnel lenses. Extruding allows for the creation of an inexpensive, thin, flat plastic sheet with an embossed Fresnel image imprinted on one side of the lens. The preferred materials, namely polyester (PET or PETG) can be utilized with or without protective additives. Protective additives may include ultraviolet light and antioxidant additives, both of which reduce yellowing and clouding of the Fresnel lens. These additives can be introduced into the resin prior to the extrusion process or during the extrusion process in a step referred to a co-extruding. A protective co-extruded cap layer is preferred, promoting longevity of the Fresnel lens.

Each Fresnel lens is secured in a focal position for focusing solar radiation passing the Fresnel lens on the absorption zone on the energy absorber by a support frame. A preferred embodiment consists of a lens retainer to which the perimeter of the lens is attached and secured on its perimeter and a pair of pivot brackets. A preferred embodiment of the solar tracking drive is comprised of a base frame, a base drive, a pivot rail, pivot bar, a pivot drive, a pivot drive plate, anchor pedestals and base bearings. Each of the support frames is pivotally attached to the base frame by base pivot bearings which pivotally attach the bottom

of the pivot bracket, thereby providing for longitudinal pivoting of the support frames respectively. The longitudinal pivoting of the support frames is controlled by the pivot drive which varies the position of the pivot bar, which is pivotally attached to the pivot rail by a pivot bar bearing. The pivot rail is pivotally attached to the top of one of side of each of the solar collector support structures by top bearings.

Lateral pivoting of the solar collector support structures is accomplished by lateral rotation of the base frame which is controlled by the base drive and facilitated by base bearings. The number of anchor pedestals and base bearings can be varied as needed to provide for adequate support and reliability. By controlling the lateral pivoting and the longitudinal pivoting of the support frames the axis of each of the Fresnel lenses can be maintained in alignment with the sun during a desired period of operation thereby maintaining the focus of the incident solar radiation on the desired absorption zones of each of the energy absorbers. The base drive and the pivot drive can each be controlled by a sensor which continually adjusts the alignment of the axis of the Fresnel lenses to match the position of the sun in the sky during a desired period of operation. This allows the Fresnel lenses to be aligned with the incident solar radiation for the time of day and season of the year.

Depending upon the material used for the Fresnel lens and the thickness of the lens, the lens may be rigid or somewhat flexible. Because the solar collector will generally be used in an exterior, unprotected environment, the support frame and the solar tracking drive must be able to withstand wind loading, moisture and temperature variations. Further, because of the wind and other environmental conditions to which the lens will be subjected, it must be securely attached to the lens retainer. This can be accomplished by many attachment means

known in the art including.

The Fresnel lens support frame as well as the solar tracking drive components, can be constructed from a variety of materials including, but not limited to, steel, aluminum or plastic. A preferred material for the support frames and the solar tracking drive is steel. A non-corrosive coating such as galvanizing, paint or powder coating, would be needed.

The base drive and the pivot drive, which comprise the drive means of preferred embodiments of the solar tracking drive, can be comprised of any of common drive mechanisms known in the art. These drive means will generally be composed of a combination of electric motors and gears. Chains and belts may also be used. The solar tracking can be accomplished through simple programming to a vary the longitudinal angle and the lateral angle based on the orientation of the solar collector, the longitude and latitude of the installation, the time of day, and the day of the year. Alternatively, a sensor can be used to continually align the axis of the Fresnel lenses with the incident solar radiation during a desired period or operation.

Many variations of geometry and grooving of the Fresnel lens may be used. As discussed above, longitudinal grooving will provide for distributed focus of the incident solar radiation on a absorption conduit. If a spot focus is desired, then the grooving will be circular. A rectangular or square lens is more practical and economical to manufacture and utilize and is more efficient for a normal application, since the grooving provides for the concentration of solar radiation incident to the corners of the lens on the absorption zone as well. One of the main advantages of the present invention is economy. One preferred embodiment utilizing rectangular lenses with longitudinal grooving, providing for a distributed focus on an

absorption conduit, and a solar tracking drive which is actuated by a sensor can be very economical and very effective compared to other solar energy collection systems known in the art. Preferably, the longitudinal axis of the solar collector installation will be aligned in an east/west direction and the lateral axis will be aligned in a north/south direction.

One or more absorption liquid pumps typically circulate the absorption liquid through absorption liquid lines to the absorption conduit and back to an energy transfer device which can be one or more of a number of energy exchange devices which are known in the art. A variety of absorption liquids may be used for circulating through the absorption conduits, which include but are not limited to water, oil or salt. Absorption liquids preferred by the present inventor are heat transfer oil for lower temperatures and molten salt for higher temperature absorption liquid applications. Salt materials which work well for high temperature applications include sodium nitrate, sodium nitrite or potassium nitrate. Heat transfer oil can be synthetic, organic or a combination of synthetic and organic oil.

A preferred embodiment of an energy transfer system comprises the energy transfer device, transfer liquid circulation lines and transfer liquid pumps. Transfer liquid is circulated through the transfer liquid circulation lines by the transfer liquid pumps to the energy transfer device and back to an energy extraction device such as a steam turbine engine. Again, any number of liquids may be used for the transfer liquid but to eliminate the necessity of another heat exchange process at the energy extraction device, water is preferred. The steam turbine engine illustrated in Fig. 10 is disclosed in U.S. Patent No. 6,533,539 to Johnson, the inventor of the present invention and provides for the flashing of heated water or other liquids from peripheral nozzles. The energy extracted by the energy extraction device, such as the steam

turbine illustrated, can be used to drive a generator or other energy conversion device. Make up water can be supplied through a make up water line which is controlled by an automated valve or pump connected to a make up water supply.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal vertical cross section of an embodiment of a solar energy collector of the present invention.

Fig. 2 is a plan view of a Fresnel lens with longitudinal grooves for a solar collector with a linear absorption zone.

Fig. 3 is a side perspective view of a solar energy collector installation of the present invention with an absorption conduit having a spherical energy absorber in a spherical energy retaining capsule.

Fig. 4 is a side perspective view of a multiple solar energy collector installation of the present invention with support frames, absorption conduit, and solar tracking drive.

Fig. 5 is a perspective detail of an embodiment of a solar tracking drive of the present invention.

Fig. 6 is a perspective detail of an embodiment of a solar energy collector installation of the present invention with secondary lens, secondary lens frame and an in-line half spherical energy absorber with a half spherical energy retaining capsule.

Fig. 7 is a cutaway detail of an in-line half spherical energy absorber of the present invention with a half spherical energy retaining capsule.

Fig. 8 is a plan view cross section of an in-line half spherical energy absorber of the present invention with absorption fins and a half spherical energy retaining capsule.

Fig. 9 is a vertical cross section of an in-line half spherical energy absorber of the present invention with absorption fins and a half spherical energy retaining capsule.

Fig. 10 is an isometric illustration of an embodiment of the solar energy collector installation, energy exchange system, and turbine engine of the present invention.

DETAILED DESCRIPTION

Referring first to Fig. 1 a cross section of a Fresnel lens **3** and energy absorber **5** components of a solar energy collector **1** of the present invention. The energy absorber as shown is an absorption conduit **7** which has an internal absorption fin **9** extending into an absorption duct **10**, which for an absorption conduit is merely the internal barrel of the pipe. The Fresnel lens axis **11** is aligned with the incident solar radiation **13**. This results in the incident solar radiation being focused to a focal point **15** as is illustrated by the incident rays **17** and the focused rays **19**. The energy absorber, which for the embodiment shown in Fig. 1, is an absorption conduit, will have an absorption zone **21** on the top surface of the absorption conduit. The absorption conduit will preferably be positioned so that the center **23** of the absorption conduit is aligned with the Fresnel lens axis. The absorption conduit, or other energy absorber, can be positioned so that the Fresnel lens top surface **25** is separated from the absorption conduit top surface **27** by a distance **29** which is equal to the focal length of the lens as shown in Fig. 1, thereby providing for the incident solar radiation to be focused at a single point in the absorption zone of the energy absorber or can be positioned such that incident solar radiation is distributed on a larger area of the absorption zone. If the incident solar radiation is focused on a single point in the absorption zone of the energy absorber, substantially higher temperatures will be experienced at the focal point. Having the focal

point coincident with the center of the energy absorber, rather than a point on the surface of the energy absorber, results in substantially reduced temperatures. Of course the focus of the incident solar radiation can be varied between the center of the absorption conduit and a point on the surface of the absorption conduit thereby varying the distribution of the focused solar radiation and thereby the maximum temperature experienced in the absorption zone. An absorption fin **9** can also be incorporated inside the energy absorber which extends into the absorption duct **10** as shown Fig. 1 and shown in Fig.'s 8 and 9 is in contact with the absorption zone, thereby assisting in the transfer of energy to the absorption liquid **33** which flows through the energy absorber. The absorption fin would normally be made of high thermal conductivity material thereby rapidly transferring the energy of the incident solar radiation from the absorption zone to the absorption liquid. An energy retaining capsule **35** can be used to encapsulate the absorption zone. The energy retaining capsule will be constructed of material with a high solar radiation transmission rate and a low thermal conductivity rate thereby providing for transmission of the focused incident solar radiation to the absorption zone of the energy absorber while minimizing the loss of energy from the energy absorber to the surrounding air **37**.

Each groove **38** of the Fresnel lens is a small piece of an aspherical surface **39**. The tilt **41** of each surface is varied with distance **42** from the center **43** of the lens to provide for focus of the incident solar radiation at the focal point of the lens. The cross section shown in Fig. 1 could be illustrative of a Fresnel lens with circular grooves which will provide for focusing of the incident solar radiation to a single focal point or could be illustrative of a Fresnel lens with longitudinal grooves as shown in Fig. 2.

The Fresnel lens of Fig. 2 with longitudinal grooves **44** results in the incident solar radiation being focused in a line rather than a single focal point. This offers an advantage of distributing the focused incident solar radiation over a larger area, thereby reducing the temperature of the absorption zone. The expanded absorption zone for embodiments utilizing a Fresnel lens with longitudinal grooves can be encapsulated in an energy retaining capsule with a high solar radiation transmission rate and low thermal conductivity rate such as glass. Similarly, a Fresnel lens with oval grooves provides for distributed focus and distribution of the concentrated energy on the energy absorber. Also, if the Fresnel lens is positioned so that the energy absorbers have absorption surfaces which are displaced radially from the focal point or focal line of the respective lenses, the larger absorption zone may be encapsulated. Other portions of the absorption conduit which do not receive focused incident solar radiation can be insulated or merely be covered with the energy retaining capsule material to reduce energy loss to the surrounding air.

A cement coating can be placed on the absorption zone to increase the absorption rate of the focused incident solar radiation. Alternatively, an energy assimilator of high thermal conductivity material can be placed on the absorption conduit or other energy absorber. Further the energy assimilator can be thermally connected to an absorption fin extending into the absorption duct, thereby increasing the energy transfer rate to the absorption liquid.

Material selection for the absorption zone of the energy absorber or energy assimilator placed on the energy absorber in the absorption zone will be selected based upon anticipated maximum temperatures and desired absorption and thermal conductivity rates. Materials that can be used include stainless steel, carbon steel, tungsten, titanium, molybdenum, rhenium,

niobium, platinum, copper and other metals and non-metallic materials. A preferred material for the absorption zone and absorption fins is tungsten due to its high thermal conductivity rate, its high melting point and its glass to metal sealing capabilities.

The energy retaining capsule **35**, whether it is spherically shaped as indicated on Fig. 1 and Fig. 3, hemispherically shaped as indicated on Fig. 6 or tubularly shaped for an absorption conduit, the capsule can be made from a number of materials including soda lime glass, borsilicate glass or quartz. Borsilicate glass is a preferred material because of its inherent impact strength and its lower thermal conductivity rate. While a spherical or hemispherical shape is preferred for a point focus due to a higher solar radiation transmission rate and a higher absorption rate, other shapes can be used, depending upon the energy distribution desired on the absorption zone. For a linear absorption zone, a cylindrical capsule is preferred on the absorption conduit.

It is preferred for the retaining capsule material to be bonded or hermetically sealed to the absorption zone or to the absorption conduit. This generally increases energy retention by the absorption conduit or other form of energy absorber. Alternatively a space may be provided between the energy absorber and the energy retaining capsule, whether the energy retaining capsule is spherically shaped, hemispherically shaped or cylindrically shaped, which may be air evacuated, thereby providing a vacuum space separating the energy retaining capsule from the energy absorber, thereby further enhancing the energy retention of the energy retaining capsule.

The Fresnel lens itself is preferably constructed of an optically clear material. These materials include but are not limited to acrylic, glass, rigid vinyl, polycarbonate, polyethylene,

polyester blends including PET and PETG respectively, poly IR, polystyrene, polyurethane, polypropylene, polyacrylonitrile, Kevlar, Nomex, rubber, germanium, silicon, zinc sulfide, quartz and other such materials. The inventor's preferred materials are polyester (PET or PETG) or a blend thereof.

A Fresnel lens can be formed or manufactured in a number of ways from the substrate materials identified above. This includes but is not limited to press thermalforming, roll thermalforming, casting, emboss extruding, injection molding, milling, lathing, or UV curing. Emboss extrusion is the preferred method of creating Fresnel lenses. Extruding allows for the creation of an inexpensive, thin, flat plastic sheet with an embossed Fresnel image imprinted on one side of the lens. The preferred materials, namely polyester (PET or PETG) can be utilized with or without protective additives. Protective additives may include ultraviolet light and antioxidant additives, both of which reduce yellowing and clouding of the Fresnel lens. These additives can be introduced into the resin prior to the extrusion process or during the extrusion process in a step referred to a co-extruding. A protective co-extruded cap layer is preferred, promoting longevity of the Fresnel lens.

Referring now to Fig. 3 and Fig. 4, a preferred embodiment of a solar energy collection apparatus of the present invention is shown. Referring to Fig. 3 the Fresnel lens **3** is secured in a focal position **45** for focusing solar radiation passing the Fresnel lens on the absorption zone on the energy absorber by a support frame **47**. For this embodiment the support frame consists of a lens retainer **49** to which the perimeter **51** of the lens is attached and secured on its perimeter and a pair of pivot brackets **53**.

Referring to Fig. 4 and Fig. 5, a preferred embodiment of the solar tracking drive is

comprised of a longitudinal pivot means, a lateral pivot means and a tracking control means. A preferred embodiment of the lateral pivot means comprises a base frame **55**, a base drive **57**, anchor pedestals **67** and base bearings **69**. Lateral pivoting **83** of the solar collector support structures is accomplished by lateral rotation **85** of the base frame **55** through a lateral angle which is controlled by the base drive **57** and facilitated by base bearings **69**. The number of anchor pedestals and base bearings can be varied as needed to provide for adequate support and reliability.

A preferred embodiment of the longitudinal pivot means comprises a pivot rail **59**, pivot bar **61**, a pivot drive **63**, a pivot drive plate **65**, base pivot bearings **71**, pivot bar bearing **77**, and top bearings **81**. Each of the support frames is pivotally attached to the base frame by the base pivot bearings **71**which pivotally attach the bottom **73** of the pivot bracket, thereby providing for longitudinal pivoting **75** of the support frames respectively through a longitudinal angle. The longitudinal pivoting of the support frames is controlled by the pivot drive **63** which varies the position of the pivot bar **61**, which is pivotally attached to the pivot rail by a pivot bar bearing **77**. The pivot rail is pivotally attached to the top of one of side **79** of each of the solar collector support structures by top bearings **81**.

A tracking control means controls the lateral pivoting **83** and the longitudinal pivoting **75** of the support frames so that the axis **11** of each of the Fresnel lenses is maintained in alignment with the sun during a desired period of operation thereby maintaining the focus of the incident solar radiation on the desired absorption zones of each of the energy absorbers. For a preferred embodiment, the tracking control means consists of a sensor which controls the base drive and the pivot drive, thereby continually adjusting the alignment of the axis of

the Fresnel lenses to match the position of the sun in the sky during a desired period of operation. An alternative embodiment of the tracking control means is a simple computer which controls the base drive and the pivot drive and continually positions the support frames, during a desired period of operation, based upon the physical orientation of the solar collector installation, the date, the time of day, and the longitude and latitude of the installation. This allows the Fresnel lenses to be continually aligned with the incident solar radiation.

Referring to Fig. 4, preferably, the longitudinal axis **109** of the solar collector installation will be aligned in an east/west direction and the lateral axis **111** will be aligned in a north/south direction.

Referring now to Fig. 6 and also Fig. 7, an in-line energy absorber **87** which has a hemispherical absorption zone which is encapsulated by a hemispherical shaped energy capturing capsule **89**. The energy absorber is affixed in line in the absorption conduit **7** with the connection to the conduit **90**, typically by flanged or mechanical joint connections. For some embodiments an optional secondary lens **91** is affixed between the Fresnel lens and the energy absorber by a secondary lens frame **93** which is affixed to the opposing pivot brackets **53** of the Fresnel lens support frame.

Referring now to Fig. 8 and Fig. 9, an embodiment of a hemispherical shaped energy absorber **87** with absorption fins **9** inserted in the flow path **97** of the absorption is shown. The absorption fins facilitate the transfer of energy from the energy absorber to the absorption liquid **33**. The energy absorber is encapsulated by an energy capturing capsule **101** of one of the preferred materials described above.

Depending upon the material used for the Fresnel lens and the thickness of the lens,

the lens may be rigid or somewhat flexible. Because the solar collector will generally be used in an exterior, unprotected environment, the support frame **47** and the solar tracking drive must be able to withstand wind loading, moisture and temperature variations. Further, because of the wind and other environmental conditions to which the lens will be subjected, it must be securely attached to the lens retainer **49**. This can be accomplished by many attachment means known in the art including, but not limited to, springs, wire, bungee cords, plastic strips or ties, glue, screws, clamps or slidable inserts. A preferred attachment means is springs. Springs allow for thermal expansion, wind loads, hail stones or any other type of contraction or expansion that the Fresnel lens may encounter. Referring to Fig. 2, spring receptacles **103**, which, in the case of a lens formed by extrusion, may be extruded out during the extrusion process or they may be punched or drilled in the perimeter **105** of the lens. Spring grommets **107** may be inserted into the spring receptacles if needed for added strength and durability. One end of the spring is inserted in the spring receptacle and the other end is attached to the lens retainer or other point on the support frame.

Referring to Figs. 3, 4 and 5, pivot bearings can be any variations known in the art. Pivot bearings can be manufactured from a number of types of commonly used material including, but not limited to, steel, graphite, plastic or ceramic. A preferred pivot bearing is a steel metal sleeve bearing. The base bearings **69** can also be steel metal sleeve bearings or a ceramic pipe, tube or sleeve bearing can be used as a heat barrier. Base frame bearings can be used as a thermal barrier between the support frame and the absorption conduit.

The Fresnel lens support frame **47** as well as the solar tracking drive components, can be constructed from a variety of materials including, but not limited to, steel, aluminum or

plastic. A preferred material for the support frames and the solar tracking drive is steel. A non-corrosive coating such as galvanizing, paint or powder coating, would be needed.

Referring to Fig. 5, the base drive **57** and the pivot drive **63**, which comprise the drive means of the solar tracking drive can be comprised of any of common drive mechanisms known in the art. These drive means may be comprised of a combination of electric motors and gears or may be pneumatically or hydraulically actuated. If the base drive and the pivot drive are pneumatically or hydraulically actuated, solar tracking will ordinarily be accomplished through the use of pneumatic or hydraulic cylinders. Chains and belts may also be used with electric motor drives.

The solar tracking can be accomplished through simple programming to a varied longitudinal angle **75** and the lateral angle **83** based on the longitude and latitude of the installation, the time of day, and the day of the year. Alternatively, the sensor can be used to continually align the axis of the Fresnel lenses with the incident solar radiation during a desired period or operation.

Many variations of geometry and grooving of the Fresnel lens may be used. As discussed above, longitudinal grooving as shown in Fig. 2 will provide for distributed focus of the incident solar radiation on a absorption conduit. If spot focus is desired so the solar energy can be concentrated to energy absorbers such as shown in Figs. 6, 7, 8 and 9, then the grooving will be circular. A rectangular or square lens is more practical and economical to manufacture and utilize and is more efficient for a normal application, since the grooving provides for the concentration of solar radiation incident to the corners of the lens on the absorption zone as well.

One of the main advantages of the present invention is economy. One preferred embodiment utilizing rectangular lenses with longitudinal grooving, providing for a distributed focus on an absorption conduit, and a solar tracking drive which is actuated by a sensor can be very economical and very effective compared to other solar energy collection systems known in the art.

Referring now to Fig. 10, a schematic of an energy production system**113** utilizing the solar energy collector **1** of the present invention shown. The incident solar radiation **17** focused on the absorption conduit **7** by one or more solar collectors, each utilizing a Fresnel lens **3** and a support frame (not shown) and being positioned by a solar tracking drive (not shown). One or more absorption liquid pumps **115** circulate the absorption liquid **33** through absorption liquids lines **117** to the absorption conduit and back to an energy transfer device **119** which can be one or more of a number of energy exchange devices which are known in the art.

A variety of absorption liquids may be used for circulating through the absorption conduits, which include but are not limited to water, oil or salt. Absorption liquids preferred by the present inventor are heat transfer oil for lower temperatures and molten salt for higher temperature absorption liquid applications. Salt materials which work well for high temperature applications include sodium nitrate, sodium nitrite or potassium nitrate. Heat transfer oil can be synthetic, organic or a combination of synthetic and organic oil.

Transfer liquid **121** is circulated through transfer liquid circulation lines **123** by transfer liquid pumps **125** through the energy transfer device **119** and back to an energy extraction device **127** such as the steam turbine engine **129** illustrated in Fig. 10. Again, any

number of liquids may be used for the transfer liquid but to eliminate the necessity of another heat exchange process at the energy extraction device, water is preferred. A preferred steam turbine engine for incorporation with the solar collector installation of the present invention as illustrated in Fig. 10 is disclosed in U.S. Patent No.6,533,539 to Johnson, the inventor of the present invention and provides for the flashing of heated water or other liquids from peripheral nozzles. The energy extracted by the energy extraction device, such as the steam turbine illustrated, can be used to drive a generator or other energy conversion device. Make up water **131** can be supplied through a make up water line **133** which is controlled by an automated valve or pump **135** connected to a make up water supply **137**.

Other objects, features and advantages of the present invention will become apparent from the preceding detailed description considered in connection with the accompanying drawings. It is to be understood, however, that the drawings are designed as an illustration only and not as a definition of the limits of the invention. Therefore, the foregoing is intended to be merely illustrative of the invention and the invention is limited only by the following claims.